Key Industry Drivers

AT&T Data Center Symposium
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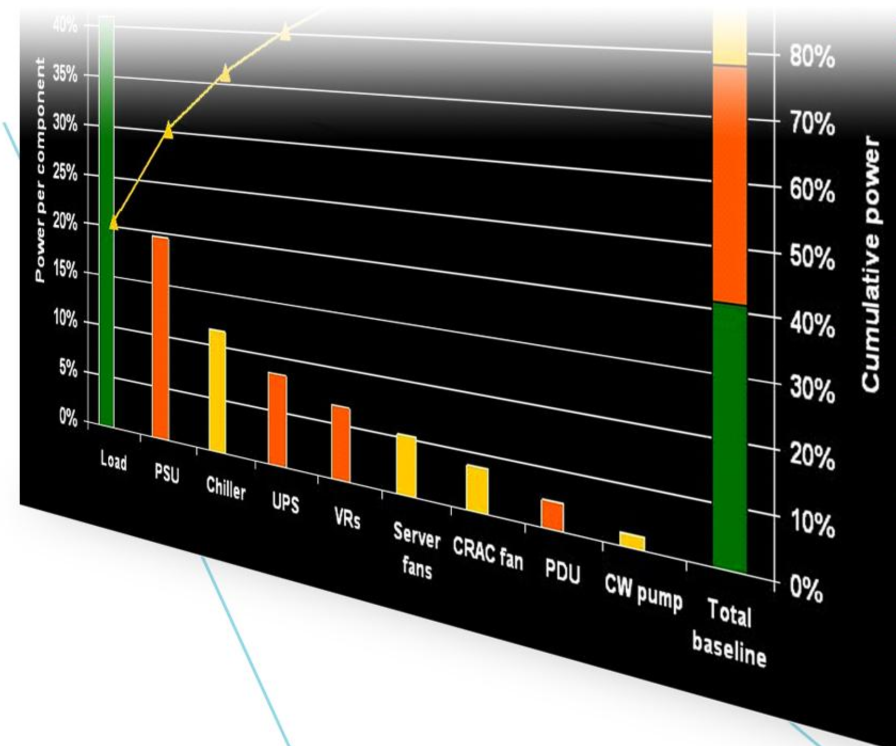
BERKELEY LAB



DOE

- Save Energy Now
- FEMP

EPA

- Energy Star servers
- Energy Star storage
- Buildings

USGBC

- LEED™ for data centers

CA Energy Commission

- New technologies

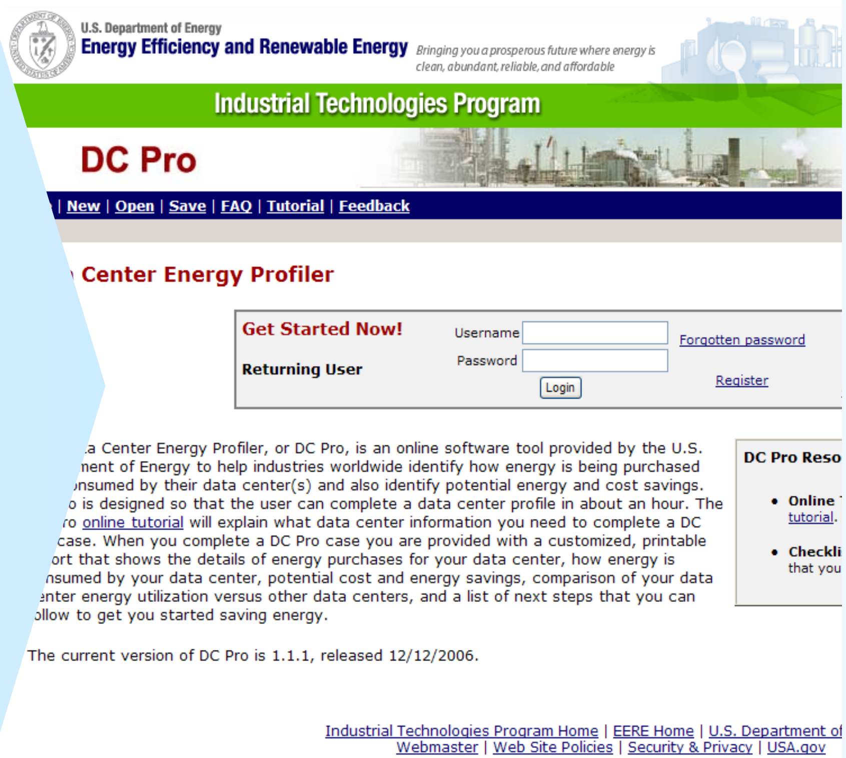
DOE Save Energy Now

- DC Pro assessment tools
- Best practices/Case studies
- Awareness training jointly developed with ASHRAE
- Certified Energy Practitioner Program
- Collaboration with Industry
  - Green Grid, ASHRAE, Uptime, SVLG, etc.
  - International - European Union, Japan, India, China
- Research - compressorless cooling

Online profiling tool

INPUTS

- Description
- Utility bill data
- System information
  - IT
  - Cooling
  - Power
  - On-site gen



OUTPUTS

- Overall efficiency (DCiE)
- End-use breakout
- Potential areas for energy efficiency improvement
- Overall energy use reduction potential
- Estimate of carbon based upon source energy
- Tracking ability

DC Pro tools

High Level Profiling Tool

- Overall energy performance (baseline) of data center
- Performance of systems (infrastructure & IT) compared to benchmarks
- Prioritized list of energy efficiency actions and their savings, in terms of energy cost ($), source energy (Btu), and carbon emissions (Mtons)
- Points to more detailed system tools

IT Module

- Servers
- Storage
- Network
- Software

Cooling

- Air handlers/ conditioners
- Chillers, pumps, fans
- Free cooling

Air Management

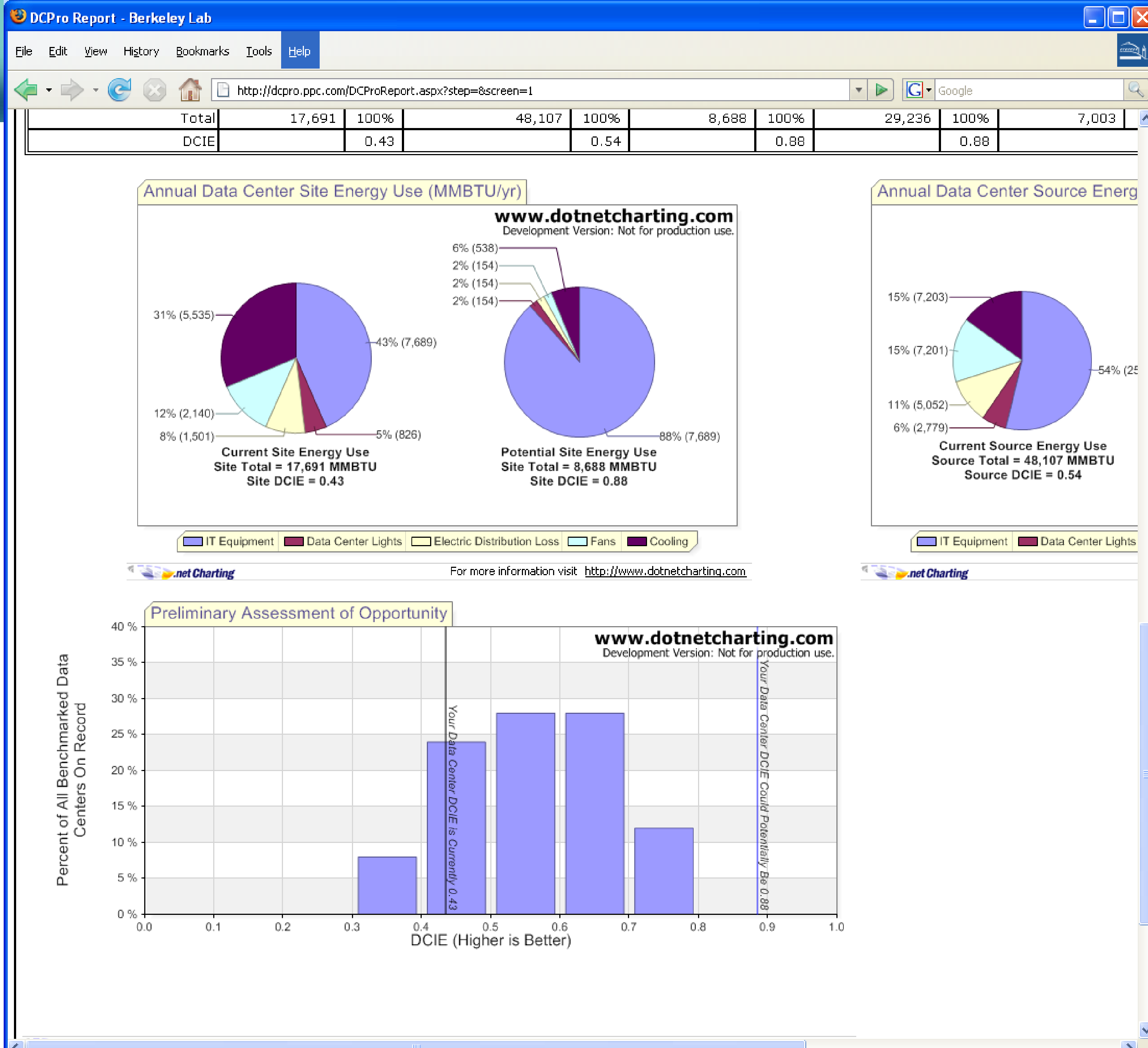
- hot cold separation
- environmental conditions

Electrical Systems

- UPS
- Transformers
- Lighting
- Motors
- Standby gen.

On-Site Gen

- Renewables
- use of waste heat


DCPro Report - Berkeley Lab
File Edit View History Bookmarks Tools Help
http://dcpro.ppc.com/DCProReport.aspx?step=&screen=1
Google
Total 17,691 100% 48,107 100% 8,688 100% 29,236 100% 7,003
DCIE 0.43 0.54 0.88 0.88
Annual Data Center Site Energy Use (MMBTU/yr)
www.dotnetcharting.com
Development Version: Not for production use.
31% (5,535)
43% (7,689)
12% (2,140)
8% (1,501)
5% (826)
Current Site Energy Use
Site Total = 17,691 MMBTU
Site DCIE = 0.43
6% (538)
2% (154)
2% (154)
2% (154)
88% (7,689)
Potential Site Energy Use
Site Total = 8,688 MMBTU
Site DCIE = 0.88
IT Equipment
Data Center Lights
Electric Distribution Loss
Fans
Cooling
.net Charting
For more information visit http://www.dotnetcharting.com
Annual Data Center Source Energ
15% (7,203)
15% (7,201)
54% (25
11% (5,052)
6% (2,779)
Current Source Energy Use
Source Total = 48,107 MMBTU
Source DCIE = 0.54
IT Equipment
Data Center Lights
.net Charting
Preliminary Assessment of Opportunity
www.dotnetcharting.com
Development Version: Not for production use.
Percent of All Benchmarked Data Centers On Record
40 %
35 %
30 %
25 %
20 %
15 %
10 %
5 %
0 %
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
DCIE (Higher is Better)
Your Data Center DCIE is Currently 0.43
Your Data Center DCIE Could Potentially Be 0.88

DCPro Report - Berkeley Lab

File Edit View History Bookmarks Tools Help

http://dcpro.ppc.com/DCProReport.aspx?Step=ECOND&screen=2

County	Carroll County
State	Georgia

Suggested Next Steps   Potential Annual Savings

Energy Management | IT Equipment | Environmental Conditions | Air Management | Cooling Plant | IT Equipment Power Chain | Lighting | Global Action

EC.A.1	Consider Air-Management measures	A low air temperature rise across the data center and/or IT equipment intake temperatures outside the recommended range suggest air management problems. A low return temperature is due to by-pass air and an elevated return temperature is due to recirculation air. Estimating the Return Temperature Index (RTI) and the Rack Cooling Index (RCI) will indicate if corrective, energy-saving actions are called for.
EC.A.2	Consider increasing the supply temperature	A low supply temperature makes the chiller system less efficient and limits the utilization of economizers. Enclosed architectures allow the highest supply temperatures (near the upper end of the recommended intake temperature range) since mixing of hot and cold air is minimized. In contrast, the supply temperature in open architectures is often dictated by the hottest intake temperature.
EC.A.4	Place temperature/humidity sensors so they mimic the IT equipment intake conditions	IT equipment manufacturers design their products to operate reliably within a given range of intake temperature and humidity. The temperature and humidity limits imposed on the cooling system that serves the data center are intended to match or exceed the IT equipment specifications. However, the temperature and humidity sensors are often integral to the cooling equipment and are not located at the IT equipment intakes. The condition of the air supplied by the cooling system is often significantly different by the time it reaches the IT equipment intakes. It is usually not practical to provide sensors at the intake of every piece of IT equipment, but a few representative locations can be selected. Adjusting the cooling system sensor location in order to provide the air condition that is needed at the IT equipment intake often results in more efficient operation.
EC.A.5	Recalibrate temperature and humidity sensors	Temperature sensors generally have good accuracy when they are properly calibrated (+/- a fraction of a degree), but they tend to drift out of adjustment over time. In contrast, even the best humidity sensors are instrinsically not very precise (+/- 5% RH is typically the best accuracy that can be achieved at reasonable cost). Humidity sensors also drift out of calibration. To ensure good cooling system performance, all temperature and humidity sensors used by the control system should be treated as maintenance items and calibrated at least once a year. Twice a year is better to begin with. After a regular calibration program has been in effect for a while, you can gauge how rapidly your sensors drift and how frequent the calibrations should be. Calibrations can be performed in-house with the proper equipment, or by a third-party service.
EC.A.6	Network the CRAC/CRAH controls	CRAC/CRAH units are typically self-contained, complete with an on-board control system and air temperature and humidity sensors. The sensors may not be calibrated to begin with, or they may drift out of adjustment over time. In a data center with many CRACs/CRAHs it is not unusual to find some units humidifying while others are simultaneously dehumidifying. There may also be significant differences in supply air temperatures. Both of these situations waste energy. Controlling all the CRACs/CRAHs from a common set of sensors avoids this.
EC.A.8	Consider disabling or eliminating humidification controls or reducing the humidification setpoint	Tightly controlled humidity can be very costly in data centers since humidification and dehumidification are involved. A wider humidity range allows significant utilization of free cooling in most climate zones by utilizing effective air-side economizers. In addition, open-water systems are high-maintenance items.
EC.A.9	Consider disabling or eliminating dehumidification controls or increasing the dehumidification setpoint	Most modern IT equipment is designed to operate reliably when the intake air humidity is between 20% and 80% RH. However, 55% RH is a typical upper humidity level in many existing data centers. Maintaining this relatively low upper limit comes at an energy cost. Raising the limit can save energy, particularly if the cooling system has an airside economizer. In some climates it is possible to maintain an acceptable upper limit without ever needed to actively dehumidify. In this case, consider disabling or removing the dehumidification controls entirely.
EC.A.10	Change the type of humidifier	Most humidifiers are heat based; ie, they supply steam to the air stream by boiling water. Electricity or natural gas are common fuel sources. The heat of the steam becomes an added load on the cooling system. An evaporative humidifier uses much less energy. Instead of boiling water, it introduces a very fine mist of water droplets to the air stream. When set up properly the droplets quickly evaporate, leaving no moisture on nearby surfaces. This has an added cooling benefit, as the droplets absorb heat from the air as they evaporate.

Previous   Save & Continue

DOE Federal Energy Management Program

- Benchmarking DOE data centers
- Assessments of Federal data centers
- Use of DC Pro tools
- Pilot adoption of technologies
- Federal procurement specifications
- Assistance with financing - ESPC contracts

EPA Energy Star

- Server Spec
- Storage Spec - in development
- Buildings (data center)
- Power supply efficiency (80 Plus program)

US Green Building Council

- LEED criteria for commercial buildings misses key attributes for data centers
- Draft criteria for new data centers was developed in collaboration with all major data center organizations and submitted to USGBC
- USGBC is reviewing the draft criteria
- Draft criteria for existing data centers is beginning

California Energy Commission

- Public Interest Energy Research (PIER) program funds research and demonstration projects with goal to improve efficiency of data centers
- CEC - PIER is sponsoring LBNL in collaboration with the Silicon Valley Leadership Group (SVLG) for development of demonstration projects
  - SVLG member companies (and others) agree to demonstrate energy efficiency technologies
  - Demonstrations shared with industry in yearly summit

PUBLIC INTEREST ENERGY RESEARCH
"Research Powers the Future"

Demonstrations that could drive the market

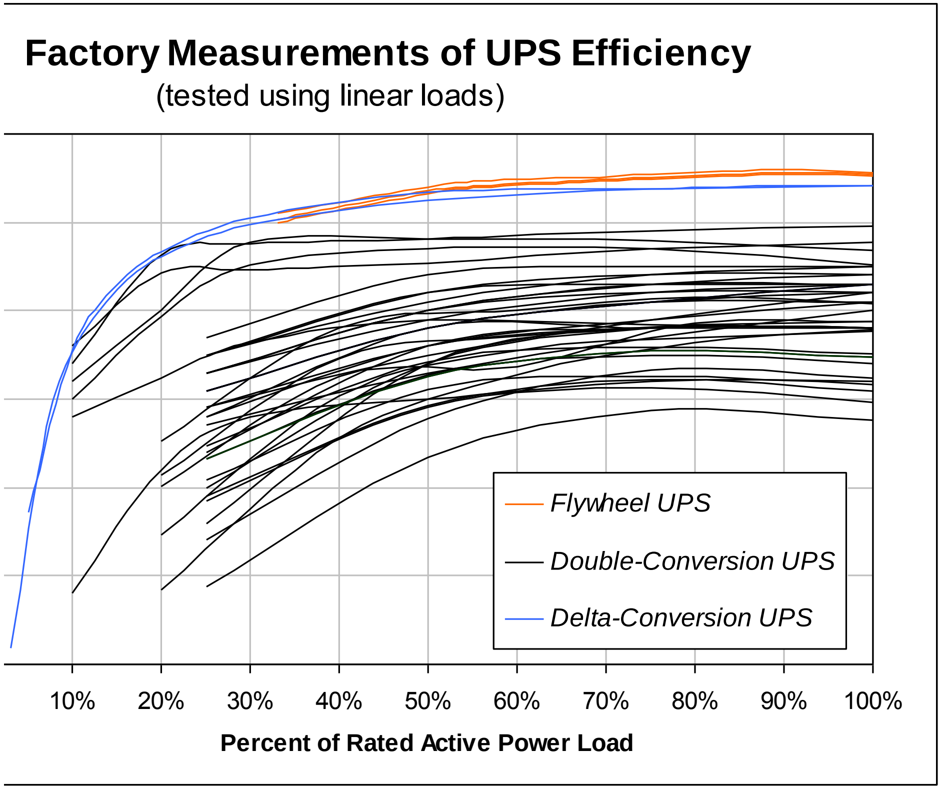
- Use of DC Power
- Improved control technologies
  - Wireless monitoring and control
  - Integrating IT and building systems

DC Power

- Demonstration in 2006 at Sun Microsystems with Intel and over 25 participating firms
- Successfully demonstrated distribution of 380V. DC
- Hundreds of data center professionals viewed the demonstration - generally positive reception except from UPS vendors
- Savings were demonstrated by eliminating power conversion losses in UPS and Power Supplies. Other losses in PDUs could also be eliminated

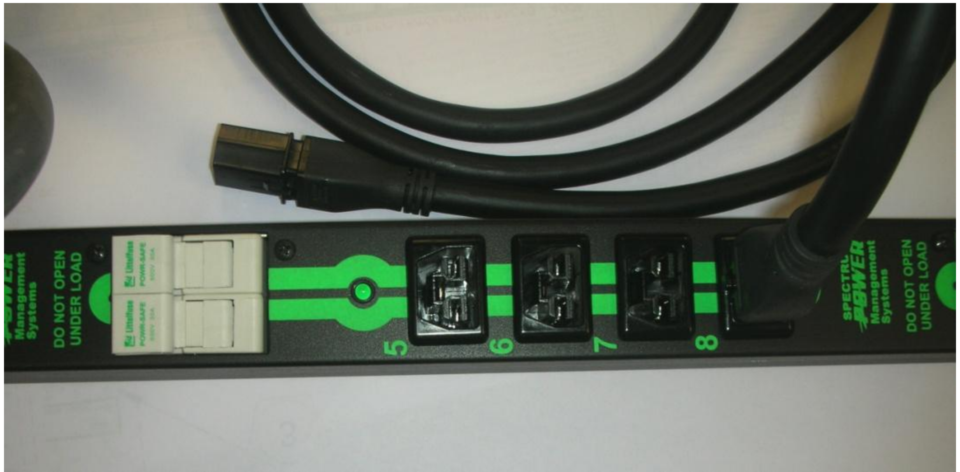
UPS systems, transformers, and PDUs efficiency

- Efficiencies vary with system design, equipment, and load
- Redundancies will always impact efficiency

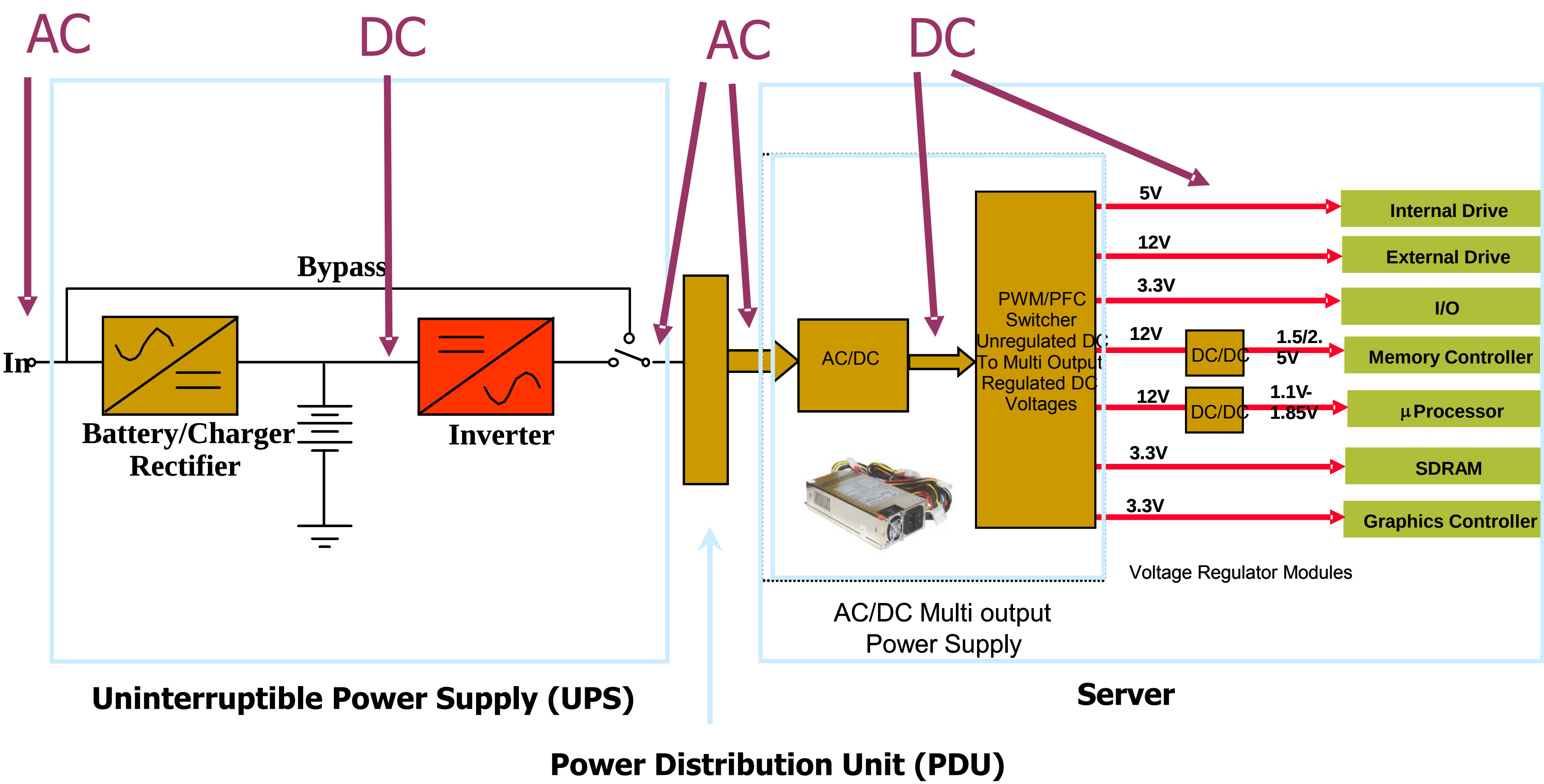


DC Power - Actions following 1st demo

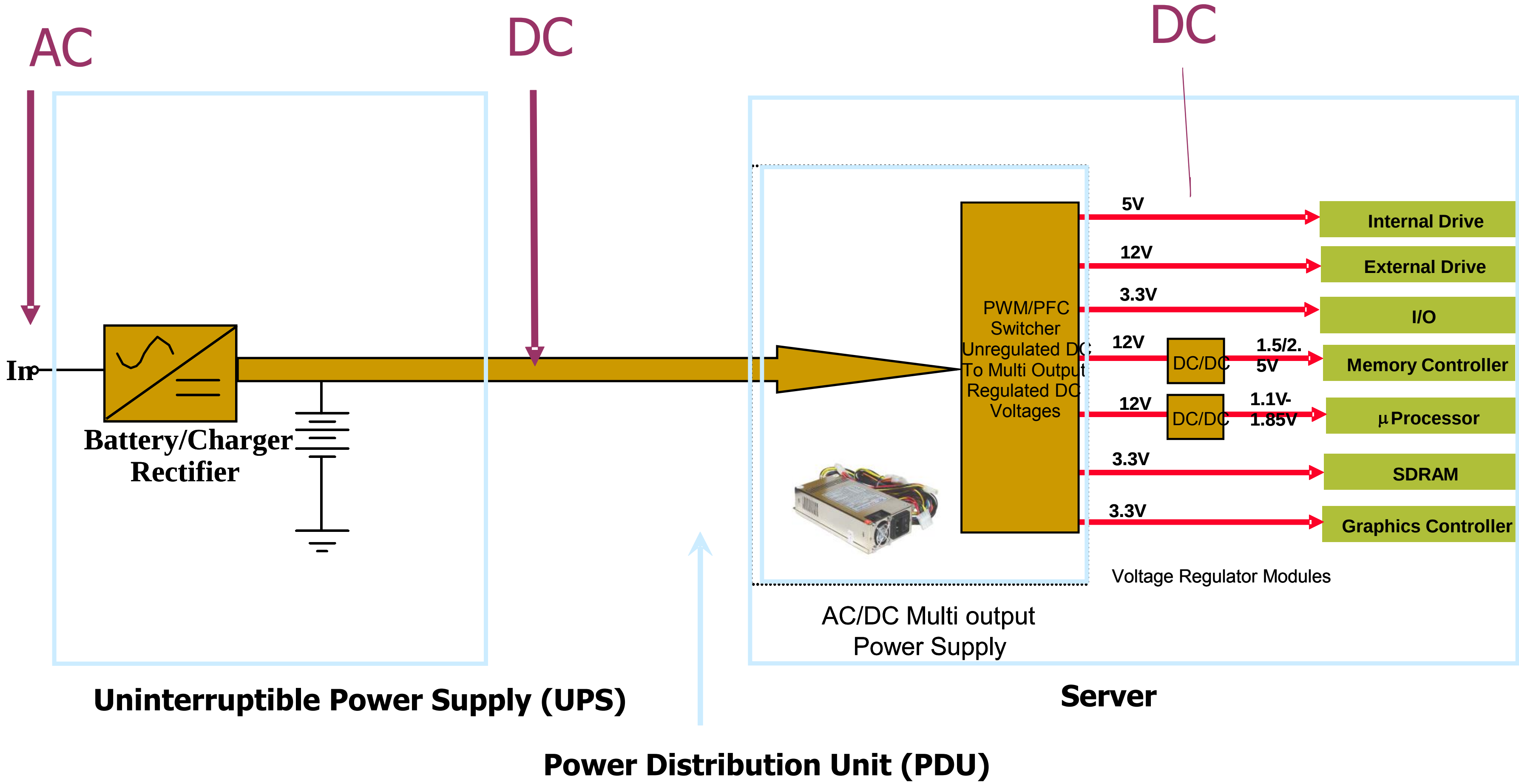
- Continued monthly discussions lead by the Electric Power Research Institute with industry partners
- Began collaboration with Europeans and Japanese
- Encouraged development of standard connectors
- Encouraged consensus on DC voltage (350-400V)
- Develop demonstrations in operating data centers



From utility power to the chip - multiple electrical power conversions



"400 V" DC -
Eliminates multiple electrical power conversions



DC Power demonstration with UC San Diego

- DC power supplied by fuel cell
- DC distribution around part of campus
- DC power from other renewable sources
- Direct DC powering of Sun Container –
  - comparison to AC
- Industry partners: Sun Microsystems, Intel, Emerson, Delta, others

DC Power

- DC power is a natural extension for telecommunications
- Telecommunication firms interested internationally

DC projects are moving ahead

Site	Location
Gnesta Municipality	Gnesta Sweden
Elicom	Toreboda Sweden
NTT	Tokyo Japan
France Telecom	Lannion France
Ericsson	Stockholm Sweden
Soderhamm Teknikpark	Soderhamm Sweden
Univ of Calif/San Diego	San Diego USA
Korean Telecom	Seoul Korea
Syracuse Univ	Syracuse NY

Improving Monitoring and Control

Wireless technology

- **Economical extensive monitoring**
- **Direct control of building systems**
- **Dashboards to visualize data**
- **Effective for retrofits**

Merging IT and building systems

- **The data center is the computer**
- **Goal is optimized power and cooling**

These control technologies are available now

Wireless Technology Demonstrations

Cost effective monitoring of many points

- Fine grained temperature monitoring
- Pressure measurements (e.g. underfloor)
- Power monitoring
- Flow monitoring
- Humidity monitoring

Wireless Technology combined with other measures enables savings

- Establish baseline
- Adjusted floor tiles
- Installed Variable Frequency Drives (VFDs)
- Installed control software
- Isolated hot-aisles
- Installed blanking panels

Project Results

Wireless sensors/software directly controlled computer room air handlers

Fan energy reduced by 66%

Total energy reduced by 21%

Annual energy savings 475,000 kWh

Eliminates >400 tons CO_2/yr

Payback: 3.1 years

Bottom-line: $42,700 per year

Merging IT and building systems

Thinking holistically:

Power chain (DC demo)

Cooling chain (e.g. multiple fans)

Environmental or power controls -

The following demonstrations show control of environmental conditions

through the use of IT equipment controlling building systems

Merging IT and building systems

Modern servers have multiple on-board sensors monitoring -

- **temperatures at various locations**
- **fan speeds**
- **cpu utilization/activity**
- **power**
- **other**

Building equipment controls are stand alone with many protocols. Often control is crude - controlling temperatures returning to the air handler. Most centers are overcooled.

BacNet is becoming the preferred open protocol standard.

Merging IT and building systems

These demonstrations used the sensors in the IT equipment to directly control the computer room air handlers. Two teams independently demonstrated this technology:

- **LBNL/Intel/IBM/HP/Wonderlich Malek/Fieldserver Tech**
- **Netapp/Cisco**

Merging IT and building systems

- Intermediate control systems are unnecessary
- Servers control to exactly what is needed by monitoring server inlet temperatures
- Control is provided for temperature and air flow

Using IT equipment sensors to control building systems

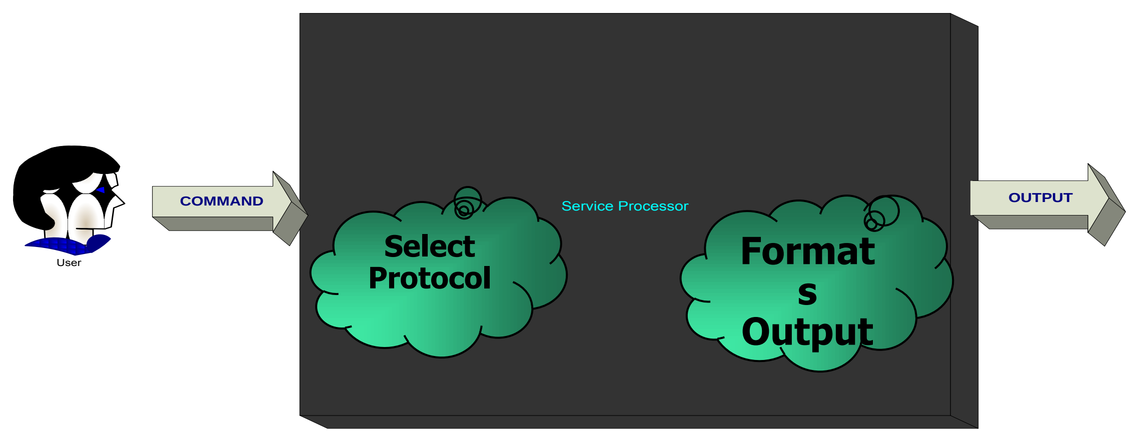
Protocol used with IT:

- SNMP (simple network management protocol) or
- IPMI (Intelligent Platform Management Interface)

Protocol that building systems use: BacNet

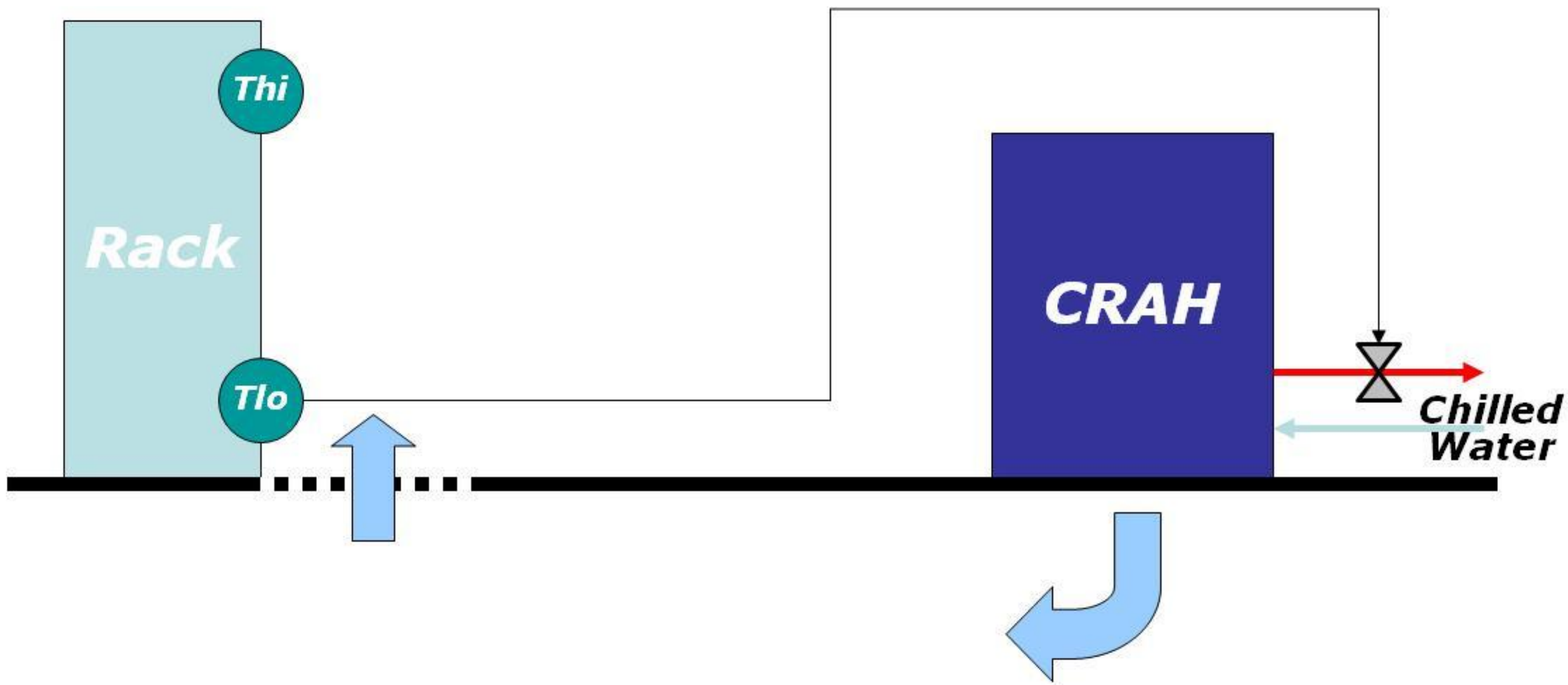
Black Box vendors exist:

- Fieldserver Technologies
- Cisco
- Others??



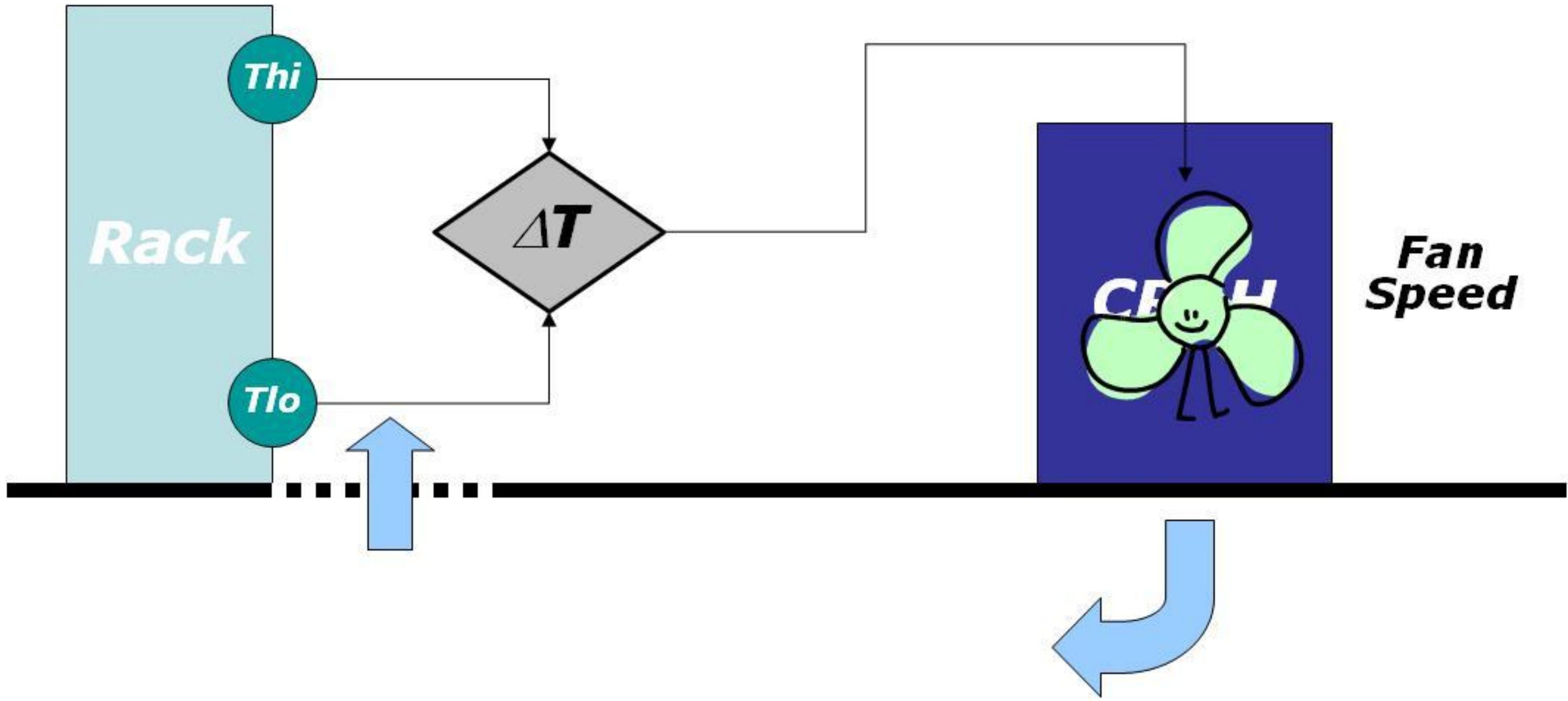
Using IT equipment sensors to control building systems

Sensors in IT equipment at the top and bottom of rack were used for control. Sensors at the bottom controlled temperature by modulating the chilled water valve



Using IT equipment sensors to control building systems

Sensors at the top controlled air flow by controlling the air handler fan speed via variable speed drives. Temperature difference between the top and bottom of rack was used for control.



IT sensors demonstrations

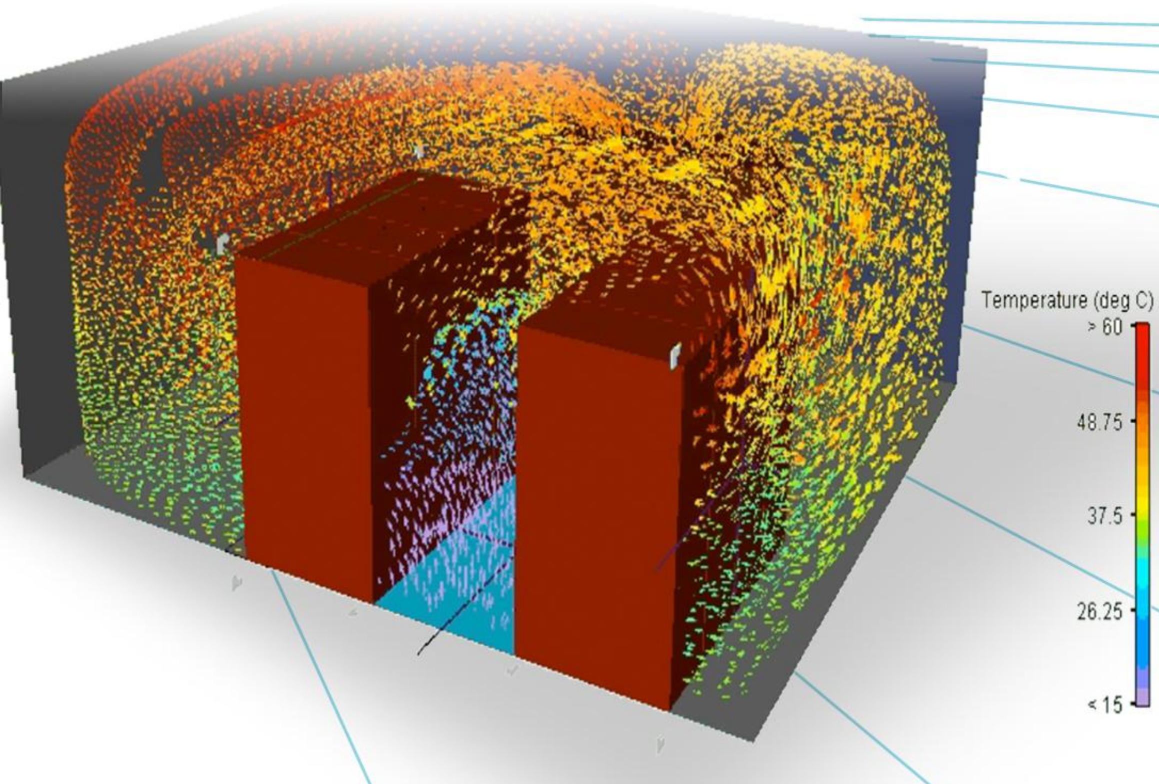
- **Showed that temperature information can be passed from the IT network to the facility management system**

- **Showed that server temperature readings can be directly used to control cooling systems**

- **Demonstrated effective two-way communication and control with off the shelf equipment**

- **No interruptions to the equipment**

- **No reconfiguration of ICT or facility management systems were necessary**



Questions/discussion

Links for more information

DOE EERE Technical Assistance Project:
http://apps1.eere.energy.gov/wip/tap.cfm

DOE Website: Sign up to stay up to date on new developments
www.eere.energy.gov/datacenters

Lawrence Berkeley National Laboratory (LBNL)
http://hightech.lbl.gov/datacenters/

ASHRAE Data Center technical guidebooks
http://tc99.ashraetcs.org/

The Green Grid Association: White papers on metrics
http://www.thegreengrid.org/gg_content/

Energy Star® Program
http://www.energystar.gov/index.cfm?c=prod_development.server_efficiency

Uptime Institute white papers
www.uptimeinstitute.org

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